



EcoHAB HARMFUL ALGAL BLOOM RESEARCH AND THE ECOHAB PROGRAM

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LTG 2 Poster 04

Background

Harmful Algal Blooms (HABs) include toxic and noxious phytoplankton, some protists, cyanobacteria, and benthic algae. These blooms can impact virtually all components of aquatic ecosystems, cause serious illness in humans in a variety of ways, and have a significant impact on water quality. Since no single Agency has the resources or mandate to address the many dimensions of the HAB problem, an interagency extramural research program on the Ecology and Oceanography of Harmful Algal Blooms (EcoHAB) was formed in 1997. This joint funding effort enhances interagency communication and eliminates funding redundancy between agencies, allowing for the most effective use of federal resources.

How Research Addresses the Water Quality MYP

MYP Science Question: The question under Long Term Goal 2 of ORD's Multi-Year Plan (MYP) as addressed by EcoHAB is: *How can multiple and possibly-related causes (eutrophication, land use change) of biological impairment (HABs, toxin production) be inferred from indicator and other observations, and cause-effect modeling?*

How Research Contributes to Outcomes

EPA-sponsored EcoHAB projects produce results that will further the scientific understanding of the relationships between nutrient inputs, coastal eutrophication, and the occurrence and consequences of harmful algal blooms (HABs). Research results will enhance the development of ecological risk assessments for nutrients, as well as the development of stressor-response models aimed at understanding and predicting the relationship between stressors such as nutrients, eutrophication, and hypoxia on aquatic ecosystems. Ultimately, the expected outcomes of the EcoHAB program as a whole are 1) enhanced HAB forecasting efforts; 2) improved control and mitigation options for decision makers concerned with managing HABs; and 3) improved bloom prevention strategies based on an advanced understanding of the conditions and processes that promote bloom formation, maintenance, and decline.

EcoHAB Objectives

EcoHAB is a competitive, interagency research program involving the following five agencies:

- National Oceanic and Atmospheric Administration (NOAA)
- National Science Foundation (NSF)
- Office of Naval Research (ONR)
- National Aeronautics Space Administration (NASA)
- EPA's Science to Achieve Results (STAR) program

- While the specific research funded by each Agency varies according to its mission, it is all united by a common goal: to provide support for research whose products will include tools, data, and models that will contribute to the development of better methods for the detection, monitoring, prediction, control, and mitigation of harmful algae and their impacts.
- EPA's earlier efforts in the EcoHAB program were largely focused on detection methods, toxin identification and life-history studies of HABs, with a heavy emphasis on *Pfiesteria*, as mandated by Congress.
- In recent years, EPA has moved away from this focus, encouraging research on other harmful algal species in an effort to better support the Agency's mission. Now, in direct support of the MYP, EPA's specific goal within the larger EcoHAB framework is to better understand the relationships between nutrient loading (eutrophication), HABs, and food web dynamics.

EcoHAB: Dinoflagellate Molecular Ecology

David Oldach, University of Maryland, Baltimore

This research developed real-time PCR assays to detect HAB species.

Science Question:

Harmful algal species are found throughout the Chesapeake Bay and Coastal Bays but identification using light microscopy is difficult when assessing species in heterogeneous environmental samples. Can rapid and sensitive assays be developed to identify HAB species in complex environmental samples?

Methods:

Sequence data for target loci were compared in a matrix and primers and probes were designed based on level of specificity desired (i.e., group-specific or species-specific). Assays were designed and validated for: *Pfiesteria piscicida*, *P. shumwayae*, *Karlodinium micrum*, *Chattonella verruculosa*, *C. of verruculosa*, *C. marina*, *C. subsalsa*, *Fibrocapsa japonica*, *Heterosigma akashiwo*, *Pseudo-nitzschia* sp. and *Aureococcus anophagefferens*.

Outcomes and Results:

- Successful development of molecular probes and techniques for rapid identification of several HAB species
- Researchers developed collaborations with local Departments of Natural Resources
- Maryland DNR utilizes this grant's PCR results for its water quality monitoring program
- Based on the successful development of probes, additional funding has been awarded to these laboratories to correlate HAB presence with human health (CDC, NC Dept. of Health and Human Services); determine spatial and temporal distribution (funding by various states, NOAA, US Sea Grant Program); and to assess presence of HAB species in sediment and ballast water (STAR, DoD).
- To date, 113 HAB sequences have been deposited to GenBank.
- All of these are accessible to the scientific community for research purposes.

****All data and accompanying figures provided courtesy of the principal investigator listed for each grant**

Health and Ecosystem Effects



EcoHAB: Physiology and Ecology of Macroalgal Blooms on Coral Reefs Off of Southeast Florida

PI: Brian E. Lapointe, Harbor Branch Oceanographic Institution, Florida

This research addresses fundamental questions regarding the recent proliferation of macroalgal HABs on coral reefs off Southeast Florida.

Science Question:

- Are macroalgal blooms in Southeast Florida linked to increasing land-based discharges of ammonium derived from sewage via groundwater and ocean outfalls?

Expected Outputs and Outcomes:

- An advanced understanding of how physical, chemical, and biological factors interact to initiate, sustain, and terminate macroalgal blooms on coral reefs in southeast Florida.
- A determination as to whether these blooms are being driven by low-level buildup of ammonium from land-based sources of nutrient pollution.

Methods:

- This project is a two-year study of the physiology and ecology of *Codium* and *Caulerpa* spp. whose methods include:
 - Measuring seasonal patterns in benthic cover via underwater digital photography
 - Measuring photosynthesis, dark respiration, optical properties, tissue C:N:P ratios and $\delta^{15}N$ values
 - Measuring the uptake of NH_4^+ and NO_3^- under different combinations of irradiance and temperature
 - Conducting controlled grazing experiments in both the lab and field to quantify the potential for generalist and specialist herbivores to control the blooms.

EcoHAB: Control of Harmful Algal Blooms Using Clay

Donald M. Anderson, Woods Hole Oceanographic Institution
Richard Pierce, Associate Investigator (More Marine Laboratory)
Richard M. Greene (EPA Gulf Ecology Division)
Michael Lewis (EPA Gulf Ecology Division)
V. Monica Bricef (Institute for Marine Biosciences, National Research Council, Canada)

This research investigates bloom mitigation strategies so that impacts to human health, fisheries and ecosystems can be minimized.



Outputs and Outcomes:

- A successful preliminary evaluation of the use of clays to mitigate harmful algal blooms, including such findings as:
 - Clay dispersal remains a promising strategy for controlling HABs and their impacts.
 - Clays are effective, fast-acting, and can be relatively selective for particular HAB species.
 - Clays may be able to remove some dissolved algal toxins in seawater.
 - Polyaluminum chloride (PAC), a chemical coagulant, has advantages and disadvantages, and should be investigated further.
 - Clays can absorb or release inorganic nutrients, but the significance and consequences are unknown.

Science Question:

Is the use of clay flocculation to remove HAB cells from the water column a promising mitigation strategy for HABs?

Methods:

Scientists used laboratory cultures, aquaria, and mesocosms to evaluate the efficiency of this technique and characterize potential effects of its use on the environment.

- This project was a partnership between academic and government scientists, addressing a highly visible and serious environmental problem in the coastal ocean
- Interactions were also initiated with clay producers, phosphate mining industry, coagulant manufacturers, environmental consulting companies and citizens groups concerned about red tide impacts.
- A planned pilot study (funded by NOAA) will address the "real-world issues" of clay dispersal and its effects in the field.

Interactions with Customers

The ultimate beneficiaries of EcoHAB research funded by all of the Agencies are the individuals and organizations who are directly impacted by HABs or who must manage these blooms and their impacts.



This EPA-funded EcoHAB grant allowed investigators to form collaborations with Maryland Department of Natural Resources and Delaware Department of Natural Resources and Environmental Control to use their technique to assay environmental water samples for their monitoring programs. In fact, Maryland DNR utilizes the PCR results to 1) rapidly assess presence of HAB species during a bloom and/or fish kill event; 2) determine if further testing such as bioassay experiments are needed in an area; and 3) inform the public and scientific community of HAB events through their website: www.dnr.state.md.us



Research results from this EPA-funded EcoHAB grant are being used by state of Florida (Department of Environmental Protection, Florida Wildlife Research Institute) as well as federal agencies (US EPA) in an on-going risk assessment of alternatives for wastewater treatment and disposal in Southeast Florida. The results are also being used by researchers and resource managers in SEFCRI (Southeast Florida Coral Reef Initiative, an element of the federal International Coral Reef Initiative, ICRI) charged with improving our understanding of land-based sources of pollution in this geographic area.



Investigators on this EPA-funded EcoHAB grant worked closely with Solutions to Avoid Red Tide (S.T.A.R.T.), a citizens group established in Florida to help find solutions for red tide problems. In order to perform pilot scale treatments of natural Florida red tides, this work required the approval and cooperation of several state and federal agencies involved in oversight of coastal water quality and resources. These included: Florida Department of Environmental Protection, Florida Marine Research Institute, EPA, and the U.S. Army Corps of Engineers.

For more information on these, and other EcoHAB grants, please visit our website at www.epa.gov/ncer